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Review Article

The Role of Medicinal Plants and their Bioactive Compounds in the Prevention and Treatment of Diabetes and Heart Diseases: An Updated Review

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Abstract: Diabetes mellitus is a metabolic syndrome defined as a group of metabolic disorders that lead to elevated blood sugar levels. This chronic elevation is caused by a deficiency in insulin secretion, insulin action, or both, resulting in disturbances in the metabolism of carbohydrates, proteins, and fats. In recent years, diabetes has become increasingly prevalent. Chemically, pharmaceutical drugs are used to mitigate the effects of diabetes and its subsequent complications; however, these medications often come with undesirable side effects, such as weight gain, gastrointestinal issues, and heart failure . On the other hand, medicinal plants can serve as a valuable source of antidiabetic drugs. Dietary restrictions, physical activity, and the use of plant-derived antidiabetic compounds are promoted as effective and safe methods for diabetes management due to their lower cost and fewer or negligible side effects. Additionally, their bioactive components, chemical characterization, and plant-based diets play a significant role in managing both diabetes and cardiovascular diseases. These approaches can help develop future strategies, such as identifying promising bioactive molecules for diabetes treatment. Natural product-based therapies play a crucial role in treating various diseases, and medicinal plants can be used for the prevention and treatment of diabetes due to their phenolic compounds, many of which exhibit antioxidant properties. Interest in medicinal plants has grown recently, forming the foundation of what is now known as alternative or complementary medicine. This review focuses on antidiabetic and cardioprotective plants, aiming to identify the potential benefits of medicinal plants in the prevention and treatment of diabetes and cardiovascular diseases through safe, cost-effective, and alternative approaches.

Keywords: Medicinal Plants, Bioactive Compounds, Diabetes Treatment, Cardiovascular Health, Natural Remedies.

1.1 INTRODUCTION

Diabetes mellitus is a metabolic disorder marked by impaired glucose absorption, abnormal glucose metabolism, and insulin resistance, affecting approximately one in every eleven adults. Over the past decades, the prevalence of diabetes has risen dramatically, surpassing projected estimates. This condition is a significant risk factor for several severe complications, particularly cardiovascular diseases. Notably, over 80% of diabetes-related deaths result from cardiovascular events, making heart disease the leading cause of mortality among diabetic individuals (Magliano *et al*., 2022). Findings from the Framingham Study indicate that people with diabetes are two to six times more likely to experience myocardial infarction and heart failure. Additionally, a recent meta-analysis identified a heightened risk of atrial fibrillation among diabetic patients, while another study demonstrated a strong association between diabetes and an increased likelihood of sudden cardiac death. Furthermore, hypertension, which is twice as prevalent in individuals with diabetes, serves as a crucial risk factor for chronic heart failure (Hughes *et al*., 2023).

Medicinal plants have been utilized for centuries and are now widely acknowledged as complementary and alternative therapeutic options. Emerging scientific research highlights the potential benefits of herbal extracts and their

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active compounds in managing various cardiovascular conditions, including atherosclerosis, hypertension, and diabetes. Natural plant-based supplements may contribute to reducing oxidative stress and inflammation—two fundamental mechanisms in the pathophysiology of both cardiovascular diseases and diabetes. Consequently, medicinal plants represent promising candidates for future strategies aimed at controlling diabetes and its associated cardiovascular complications (Wang *et al*., 2021).

Medicinal plants have long been a cornerstone of traditional medicine and herbal treatments across different cultures. Today, 80% of the global population still relies on medicinal plants due to their availability, affordability, promising efficacy, and the desire to avoid the adverse effects of synthetic drugs. Most medicinal plants are non-toxic; however, some exhibit high toxicity to both humans and animals. Scientists estimate that there are approximately 250,000 to 500,000 medicinal plant species worldwide, yet only a small fraction is used as food for humans and animals, and an even smaller proportion has been utilized for medical treatments. Active compounds used in traditional medicine are obtained from whole plants or specific parts such as roots, leaves, bark, or seeds. The extraction of bioactive compounds depends on factors such as the solvent used, extraction temperature, and processing methods. Three classical extraction techniques include Soxhlet extraction, maceration, and hydrodistillation (Okoye *et al*., 2014).

2.1 Study Importance

The interest in herbal products is increasing due to their medical benefits, minimal side effects, and economic considerations. Various plants are used for different diseases, and their extracts are prepared from specific plant parts. This article focuses on medicinal plants used in the prevention and treatment of diabetes and cardiovascular diseases.

2.2 Diabetes Mellitus

Diabetes mellitus is a syndrome characterized by impaired carbohydrate metabolism, leading to elevated blood sugar levels due to psychological or physiological factors, excessive sugar consumption, genetic predisposition, or insulin secretion disorders. The Greek physician Aretaeus first described diabetes around 200 BCE, noting that affected individuals urinate excessively, thus coining the term Diabetes, derived from the Greek word meaning “to flow through.” Later, in 1674, Thomas Willis added the Latin term Mellitus, meaning “honey-sweet,” to describe the sugary nature of diabetic urine (Wang, 2021). Arab scholars also contributed significantly to understanding diabetes, its causes, and complications. Notably, Al-Razi (Rhazes) and Ibn Sina (Avicenna) provided detailed descriptions of the disease, including its complications such as gangrene (Sheikhly & Shubber, 1989). In a healthy individual, blood glucose levels range between 80-100 mg per 100 mL of blood (approximately 1 g/kg of blood). Insulin is secreted when glucose levels rise after a meal, converting excess glucose into glycogen, which is stored in the liver and muscles for later use. Normally, glucose levels return to baseline within two hours. However, diabetes is a major health concern due to its clinical and epidemiological significance, as well as its acute and chronic complications. Acute complications include ketoacidosis, while chronic complications involve renal failure due to increased glomerular membrane permeability, leading to protein loss, hypoalbuminemia, and edema. Additionally, diabetes can cause neuropathy, retinopathy, and has been linked to hypertension. It also inhibits the conversion of glucose to pyruvate in muscles, leading to biochemical changes associated with diabetes (Rawi *et al*., 2011).

2.2.1 Types of Diabetes Mellitus

Diabetes mellitus exists in several forms, primarily determined by the amount of insulin produced by pancreatic beta cells (El-Abhar *et al*., 2003).

2.2.1.1 Type 1 Diabetes

Also known as Insulin-Dependent Diabetes Mellitus (IDDM) or Juvenile Diabetes, this form primarily affects children but can also develop in adults. It results from an autoimmune destruction of pancreatic beta cells by T-cells, leading to insulin deficiency. In North America and Europe, Type 1 diabetes accounts for approximately 10% of all diabetes cases (El-Dakhakhny *et al*., 2003).

This type is often triggered by environmental factors or viral infections such as mumps, influenza, enteroviruses, and congenital rubella. Unlike Type 2 diabetes, Type 1 diabetes does not respond to oral hypoglycemic agents and requires insulin injections, as the destruction of beta cells leads to severe or complete insulin deficiency (Jastreboff & Ania, 2024).

2.2.1.2 Type 2 Diabetes

Known as Non-Insulin Dependent Diabetes Mellitus (NIDDM) or Adult-Onset Diabetes, this form primarily affects individuals over 40. It results from insulin resistance, where tissues fail to respond effectively to insulin. Approximately 90% of diabetes cases worldwide belong to this category. Key metabolic abnormalities in Type 2 diabetes include obesity, hypertension, and dyslipidemia, all of which increase the risk of cardiovascular diseases (Andrews *et al*., 2011).

Insulin resistance in Type 2 diabetes can occur due to:

1. Abnormal insulin molecules
2. Increased circulating anti-insulin antibodies
3. Defective insulin receptors on target tissues (most common)
4. Unlike Type 1 diabetes, Type 2 rarely leads to significant ketone body accumulation (Huang *et al*., 2020).

2.2.1.3 Gestational Diabetes

Gestational diabetes is classified under Type 2 diabetes and results from pregnancy-related hormonal changes, particularly progesterone, which stimulates the secretion of growth hormone, leading to insulin resistance in genetically predisposed women. Approximately 20-50% of women who experience gestational diabetes are at risk of developing Type 2 diabetes later in life. Gestational diabetes is more common in older, overweight women and those with multiple pregnancies. It occurs due to the inability of maternal insulin to regulate blood sugar effectively. A key diagnostic indicator is the birth of a macrosomic (large) baby, which may be associated with congenital heart or nervous system defects (Sweeting & Arianne, 2024).

1.2.2. Causes of Diabetes Mellitus

Numerous studies have identified various factors contributing to diabetes, which can be classified into biological factors (both primary and secondary) and psychological factors.

2.1 Biological Factors

2.1.1 Primary Causes (Syarifuddin *et al*., 2022)

1. Insulin Deficiency – The primary cause of insulin-dependent diabetes (Type 1) is a deficiency in insulin secretion. This deficiency can result from benign or malignant pancreatic tumors, infectious diseases, pancreatic removal (pancreatectomy), or genetic and autoimmune disorders.
2. Genetics – Studies on twins suggest a strong genetic component in diabetes. A genetic link has been identified between human leukocyte antigen (HLA) types B15 and B8 and diabetes susceptibility.
3. Lack of Insulin Receptors – Some individuals may lack functional insulin receptors, impairing insulin transport to muscles and storage tissues.
4. Immune Dysfunction – Research indicates that diabetics often exhibit immune system malfunctions, where the body attacks insulin-producing beta cells under specific environmental conditions.

2.1.2 Secondary Causes

1. Obesity – Around 82% of diabetic adults suffer from obesity, which increases insulin resistance.
2. Pituitary Gland Dysfunction – Dysfunction can lead to excessive secretion of growth hormone, contributing to diabetes.
3. Elevated Adrenaline Levels – Increased adrenaline production can interfere with insulin function.
4. Steroid Overuse – Excessive use of steroid medications, especially cortisol, is associated with the development of diabetes.

2.2 Psychological Factors

Studies indicate that diabetes may develop following traumatic or distressing events. Psychological stress is a significant risk factor for metabolic disorders, including diabetes (Simmons, David, 2023).

2.3 The Link between Diabetes and Cardiovascular Diseases (CVDs)

Diabetes is a chronic condition that significantly increases the risk of cardiovascular diseases (CVDs), which are the leading cause of death worldwide. Heart failure is the most common cause of mortality among diabetic patients (Sun *et al*., 2021).

2.3.1 Mortality Risk in Diabetics

Research shows that:

- 44 of deaths among individuals with Type 1 diabetes (T1DM) are due to CVDs.
- 52 of deaths among those with Type 2 diabetes (T2DM) are linked to heart disease.

Additionally, cardiovascular risk increases proportionally with blood glucose levels, even before reaching diabetic thresholds (Imourani *et al*., 2019). Therefore, a key goal in diabetes management is early detection and risk management for cardiovascular complications. Diabetic adults are:

- 2-4 times more likely to die from myocardial infarction (MI), ischemic heart disease, congestive heart failure, or stroke compared to non-diabetics (Gaidai *et al*., 2023).

2.3.2 Mechanisms Linking Diabetes and Heart Disease
Several metabolic abnormalities contribute to CVD development in diabetics, including:
- Hyperglycemia (High Blood Sugar)
- Hypertension (High Blood Pressure)
- Obesity
- Dyslipidemia (Abnormal Lipid Levels)
- Insulin Resistance (IR)

Additionally, CVD progression in diabetics is linked to:
- Increased oxidative stress
- Hypercoagulability (excessive blood clotting)
- Endothelial dysfunction (weakened blood vessel lining)
- Autonomic neuropathy

Moreover, diabetes-related heart diseases are influenced by genetic and cellular metabolic dysfunctions, often triggered by factors such as glucose toxicity, advanced glycation end-products (AGEs), smoking, obesity, and chronic hyperglycemia (Mosenzon *et al*., 2021).

4. Medicinal Plants
Medicinal plants are defined as plants that contain therapeutic properties in their whole structure or specific parts, helping treat or alleviate various diseases. These plants can influence human and animal physiology, affecting organ function as either stimulants or inhibitors. Additionally, they impact external and internal parasites by either inhibiting, killing, or repelling them (Srivastava, 2018).

Medicinal plants can be classified into :
- Wild species – These grow naturally and sustain themselves in ecosystems.
- Domesticated species – These have been cultivated through human selection and breeding and require management for survival.

Herbal medicine has played a primary role in complementary medicine systems and has been widely used since ancient times. Its success has encouraged the use of medicinal plants in modern drug development (Ti, Huihui, 2021).

4.1 Phytochemical Composition of Medicinal Plants
According to Seigler (2012), plant chemical compounds are divided into:

4.1.1 Primary Metabolites
These compounds are not medicinally active but are essential for plant growth, reproduction, and energy metabolism, including:
- Carbohydrates
- Amino acids

4.1.2 Secondary Metabolites
These organic compounds do not participate in plant growth, reproduction, or development but serve as defense mechanisms against pests and microbes. Many of these compounds are utilized in medicines, dyes, and flavoring agents. Based on their chemical properties, they include:
- Volatile oils
- Alkaloids
- Terpenes and terpenoids
- Phenolics
- Tannins
- Glycosides

According to Tsao (2010), different parts of plants are used for medicinal purposes:

4.2 Medicinal Plant Parts and Their Uses
1. Roots – Many plant roots are used for medicinal purposes, including:
- Fibrous roots (e.g., Urtica dioica – Stinging Nettle, family Urticaceae)
- Taproots (e.g., Glycyrrhiza glabra – Licorice, family Leguminosae)
- Tuberous roots (e.g., Harpagophytum procumbens – Devil's Claw, family Pedaliaceae)

2. Rhizomes – These underground stems store nutrients and sprout new shoots:
- Piper methysticum (Kava) – Family Piperaceae
- Zingiber officinale (Ginger) – Family Zingiberaceae

3. Bulbs – Swollen underground stems surrounded by fleshy leaves:
- Allium cepa (Onion) – Family Liliaceae
- Allium sativum (Garlic) – Family Liliaceae

4. Tubers – Underground storage stems with indistinct nodes and internodes:
- Hypoxis sp. (African Potato)
- Family Hypoxidaceae

5. Bark – The outer protective layer of tree stems, rich in medicinal compounds:
- Cinchona sp. – Source of quinine, used to treat malaria
- Cinnamomum camphora (Camphor tree)

6. Leaves – Used either alone or as part of herbal remedies:
- Ginkgo biloba –
- Family Ginkgoaceae

7. Aerial Parts – The entire above-ground portion of the plant:
- Hypericum perforatum (St. John's Wort)
- Family Hypericaceae

8. Flowers – Widely used in traditional medicine:
- Syzygium aromaticum (Clove)
- Hibiscus sabdariffa (Roselle) – Family Malvaceae
- Calendula officinalis (Marigold) – Family Asteraceae

9. Fruits – Often used in herbal medicine:
- Pimpinella anisum (Anise)
- Family Apiaceae
- Punica granatum (Pomegranate)
- Peels are used medicinally
- Citrus sp. (Lemon)
- Peels used for their therapeutic benefits

10. Seeds – Sometimes used separately or with fruits:
- Ricinus communis (Castor oil seed)
- Family Euphorbiaceae

11. Stems – Certain woody stems and branches have medicinal properties:
- Salvadora persica (Miswak tree)
- Family Salvadoraceae, used as a natural toothbrush

Medicinal plants continue to be a crucial resource for modern pharmacology, providing compounds for disease prevention and treatment.

5.2 Phenolic Compounds in Plants

Phenolic compounds are low molecular weight organic molecules derived from secondary metabolism in plants. These compounds are aromatic organic structures, primarily consisting of a benzene ring bonded to one or more hydroxyl (-OH) groups. Most phenols are colorless, odorless, bitter-tasting, and sensitive to high temperatures. They tend to be water-soluble and are often found in plants as glycosides, stored in cell walls or vacuoles in a liquid state. The position and number of hydroxyl groups influence their antimicrobial activity. For instance:
- Pyrogallol and Catechol are toxic phenols.

5.2.1 Biological Role of Phenols

Phenolic compounds play a crucial role in:
- Plant growth and reproduction

- Defense mechanisms against environmental stresses such as:
- Low temperatures
- Ultraviolet (UV) radiation
- Nutrient deficiencies
- Bacterial, fungal, and insect infections

Phenolic compounds strengthen plant cell walls, making them less permeable to water and gases. They contribute to plant rigidity and structural stability and serve as natural resistance factors.

5.2.2 Classification of Phenolic Compounds

Phenolic compounds are broadly categorized into several classes, including:

- Phenolic acids
- Flavonoids (most abundant)
- Tannins
- Stilbenes
- Lignans
- Xanthones
- Anthraquinones
- Naphthoquinones
- Isocoumarins (Dykes & Rooney, 2007).

5.2.3 Simple Phenols

Simple phenols contain one hydroxyl (-OH) group directly attached to a carbon atom within a benzene ring. The functional group (-R) can be substituted at different positions, leading to ortho (1,2-), meta (1,3-), or para (1,4-) arrangements (Manach *et al*., 2004).

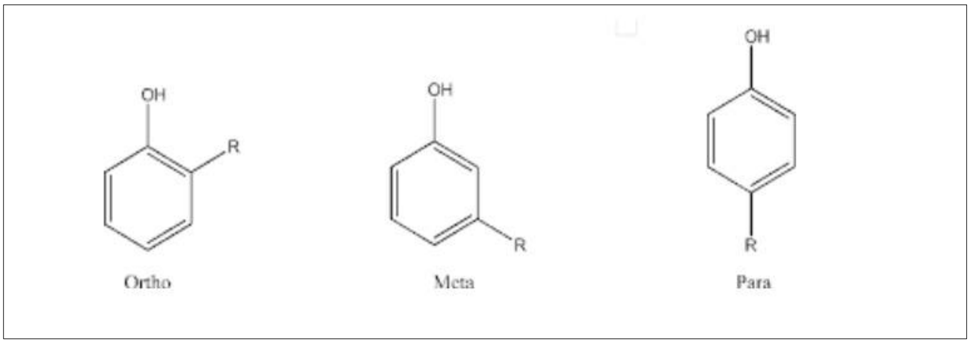

Figure 2-1: Simple Phenols

2.1.5.2 Phenolic Acids

Phenolic acids represent the basic unit for the construction of other phenolic compounds. These are simple phenolic molecules that have an aromatic ring attached to a carboxyl group (-COOH). At least one of the hydrogens is replaced by a hydroxyl group (-OH). They are divided into two categories:

1. Acids derived from Hydroxycinnamic Acid, which contains nine carbon atoms (C6-C3).
2. Acids derived from Hydroxybenzoic Acid, which contains seven carbon atoms (C6-C1).

Many studies have demonstrated that phenolic acids and their derivatives possess strong therapeutic properties, including antioxidant, anti-tumor, anti-inflammatory, antimicrobial, antifungal, and antiviral activities (Yang *et al*., 2023).

1.2.1.5.2 Hydroxycinnamic Acid Derivatives

These are more abundant than Hydroxybenzoic derivatives and include a range of acids such as caffeic acid, p-coumaric acid, ferulic acid, and sinapic acid. These acids often exist in combined forms as sugar derivatives or esters of acids such as shikimic, tartaric, and quince acids (Figure 2-2). Chlorogenic acid forms when quince acid combines with caffeic acid, and it is found in high concentrations in coffee and many fruits. Ferulic acid is one of the most prevalent phenolic acids in seeds and is abundant in the outer parts of seeds. Hydroxycinnamic acids are present in all parts of the fruit, particularly the outer parts during maturation, and their concentration decreases as the fruit size decreases (da Silva *et al*., 2023).

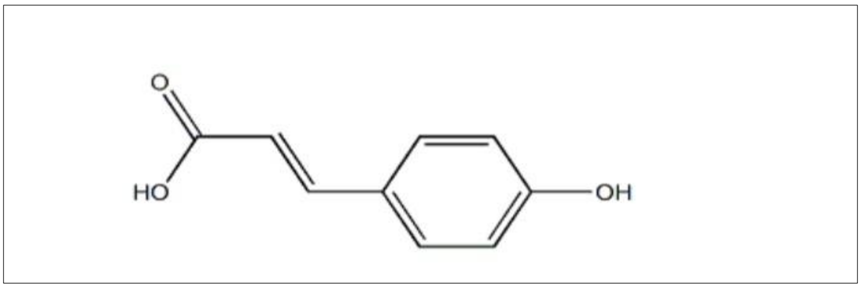

Figure 2-2: Hydroxycinnamic Acid

2.2.1.5.2 Hydroxybenzoic Acid Derivatives

The structure of these acids consists of a C6-C1 skeleton, and they are typically found in small quantities in edible plants, except for onions and certain red fruits (Figure 2-3). Tea is considered an important source of these acids. Ellagitanins and gallotannins are essential compounds for building tannins, both of which are derived from hydroxybenzoic acid (Tsagogiannis, 2024).

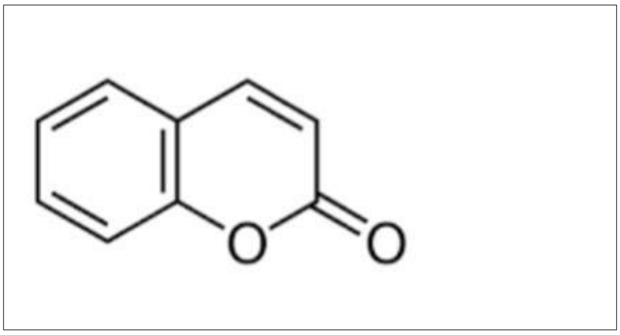

Figure 2-3: Hydroxybenzoic Acid

2.5.2 Flavonoids

Flavonoids are water-soluble pigments found in plants, typically bound to sugars as glycosides. They are widely distributed in nature and can be found in almost all parts of the plant, including flowers, branches, leaves, roots, and fruits. Their name is derived from the Latin word *Flavus*, which means yellow. Flavonoids contribute to the taste, flavor, and attractive colors of plants, which can appeal to insects and birds. They also play a protective role for the plant by giving it a distinctive taste that repels insects. Flavonoids represent a broad group of phenolic compounds in plants, with about 8,000 flavonoid compounds identified. These compounds are soluble in strong bases like sodium hydroxide. Their high polarity, resulting from the presence of multiple hydroxyl groups or sugar molecules, makes them highly soluble in polar solvents such as ethanol, methanol, and water. Less polar flavonoids, such as flavonones and flavanones, dissolve in less polar solvents like ether and chloroform .

Figure (4-2): Flavonoid Structure (Taniguchi, Masahiko, 2023).

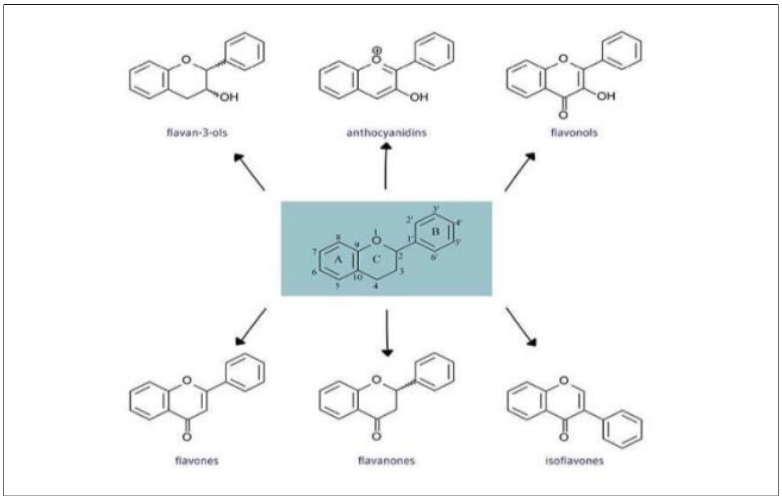

Figure 4-2: Flavonoids

3.5.2 Coumarin

In 1820, the scientist Vogal first isolated coumarin from Tonka beans (Dipteryx odorata), a plant from the legume family. The name was derived from the French term for Tonka beans, coumarou. Coumarin is considered one of the simplest phenolic compounds. It has a bitter taste and a strong, aromatic fragrance, and is soluble in alcohol. It is found in fenugreek seeds and aniseed. Coumarins have antifungal effects due to the presence of the compound Hydro-cinnamic acid (Figure 2-5). Their structure is similar to that of vitamin K, which leads to interference with coagulation biosynthesis, and their effectiveness is reduced when taken orally (Carneiro, Aitor, 2021).

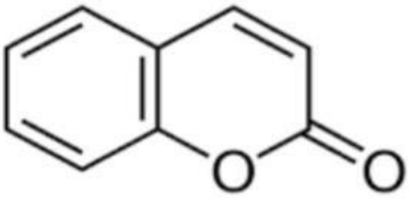

Figure 2-5: Coumarin

4.5.2 Tannins

Tannins are phenolic substances with high molecular weights ranging from 500 to 3000 Dalton. They form complexes with sugars, nucleic acids, and alkaloids. Due to their ability to bind with proteins and prevent their breakdown, they are used in the leather tanning process by combining with proteins, rendering them unable to decompose by enzymes, turning soft hides into hard, non-decaying leather. They have an astringent effect by binding to proteins and are used to treat diarrhea, burns, surface wounds, and gum inflammation through mouth rinses. They have a bitter taste and an unpleasant flavor, responsible for the taste in many fruits and vegetables. They dissolve in alcohol, acetone, and water, as shown in Figure (2-6) (Pizzi, 2021).

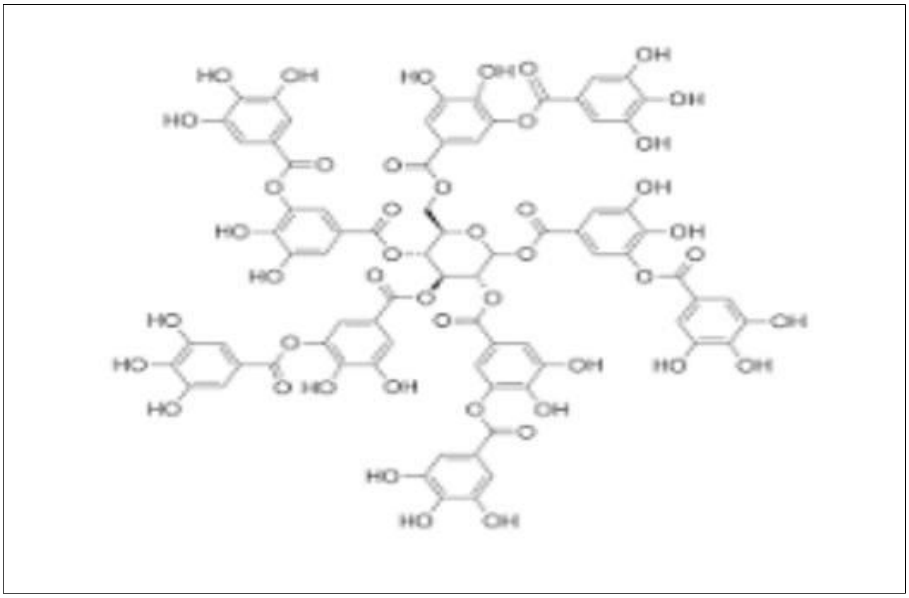

Figure 2-6: Tannins

5.5.2 Lignins

These compounds are produced through the oxidation of two phenyl propane units and are often found in free form or bound to sugars. Compounds that belong to this group include Adlercreutz and secoisolariciresinol (Figure 7-2). Recently, there has been increased interest in these compounds due to their anti-cancer properties and other effects (Ma, Qingzhi, 2024).

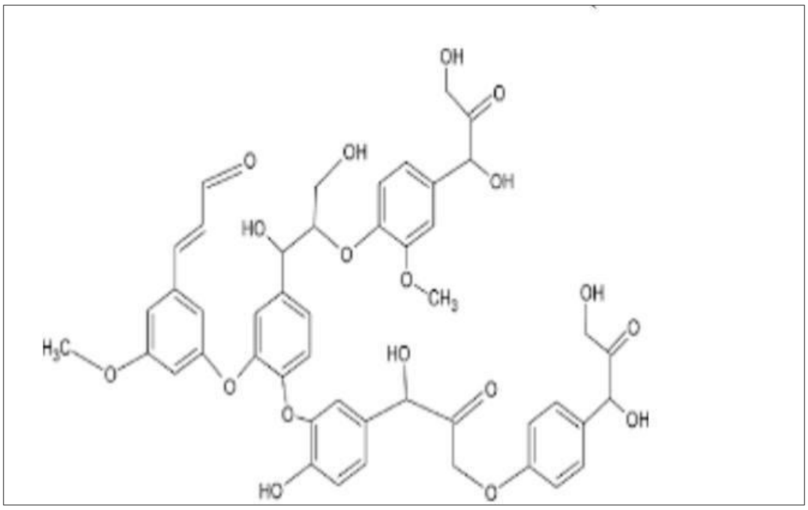

Figure 2-7: Lignins

6.2 The Role of Medicinal Plants in Treating Diabetes and Heart Diseases

The advancements in the fields of chemistry and biochemistry during the 19th and 20th centuries greatly contributed to the growth of pharmaceutical science. Through this development, many drugs were created to meet medical needs in laboratories as a result of analytical, toxicological, pharmaceutical, and clinical studies based on the principles of efficacy, harm, and quality. About a quarter of the available drugs are of herbal origin, and in many cases, the desired active substance is replicated from plants in a laboratory environment (Surrendransurya *et al*., 2014).

In recent years, various factors such as medical and economic issues arising from the severe side effects of synthetic drugs, environmental movements driven by pollution in industrial countries, and the threat of many chronic diseases that cannot be cured yet, have led to a resurgence in herbal medicine. According to reports from the World Health Organization (WHO), 25% of current medications are derived from medicinal plants, and 30% of the drugs sold globally contain plant-based raw materials. Additionally, 3-5% of patients receive herbal treatments as their primary therapy. WHO reports that 80% of people today use over 400 plants and more than 120 natural products, along with various vitamins and minerals, for treating diabetes. Some herbs have been shown to lower blood sugar levels; however, test results can vary based on several factors. Each herb contains thousands of components, and only a few of them may be therapeutically effective. Moreover, different parts of the plant may contain more than one herb with synergistic effects (Nabarun Mukhopadhyay *et al*., 2019).

In recent decades, strategies for treating diabetes have improved. However, medicinal plants have been used by humanity since the dawn of time to maintain general health. Since ancient times, medicinal plants have remained one of the primary natural resources globally. Many tribes have contributed to the knowledge base concerning the medicinal properties of plants, and these plants remain in high demand in both developed and developing countries. The WHO estimates that 80% of the world's population relies on traditional medicine to meet their primary health care needs, and most types of treatments involve plant-based remedies. Even modern pharmacopeias still consist of at least 25% plant-derived medicines, and many other semi-synthetic drugs are built upon isolated compounds from plants (Maryam Khalid Rizvi *et al*., 2022).

Science has shown that medicinal plants have been successfully used to lower blood sugar levels in both preclinical and clinical studies. For instance, a study demonstrated that garlic offers protective effects against diabetic retinopathy in adult rats. A number of phytochemicals with anti-diabetic properties have been discovered in medicinal plants, which vary in their chemical composition, and are classified into major groups (Vijayaraj *et al*., 2016).

According to the World Health Organization (WHO), chronic diseases—including coronary heart disease (CHD), cancer, diabetes, and obesity—account for 59% of global deaths. In 2001 alone, a total of 56.5 million deaths were reported worldwide (Niu *et al*., 2019). Among these conditions, coronary heart disease remains the leading cause of both morbidity and mortality globally, driving significant interest in identifying plants with cardioprotective and heart-strengthening properties, along with the phytochemicals responsible for these effects.

Research suggests that the complex interactions of multiple plant compounds contribute significantly to their health benefits, as many plants contain diverse phytochemicals with therapeutic potential against various diseases. While hundreds of plant-based medicines are utilized in traditional medicine, many remain scientifically unexplored, and clinical evidence supporting their efficacy is still limited. However, for certain plants—particularly those used in supplements and herbal remedies—clinical studies indicate potential benefits in reducing the prevalence of chronic diseases and lowering mortality rates in both the general population and high-risk individuals .Notably, the most consistent recommendations for coronary heart disease prevention emphasize dietary modifications, regular physical activity, and the use of specific plant-based supplements. These include artichoke (Cynara scolymus), garlic (Allium sativum), ginkgo (Ginkgo biloba), guggul (Commiphora mukul), red wine (Vitis vinifera), saffron (Crocus sativus), and tea (Camellia sinensis) (Zol *et al*., 2021).

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